4.—AN EXAMINATION OF CLAYS FROM MARCHAGEE AND CARDABIA, W.A.

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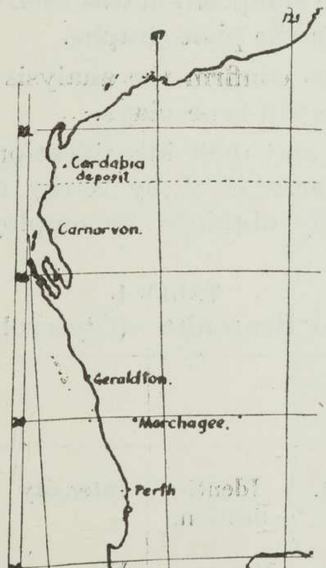
ABSTRACT.

The mineralogical composition of three samples of clay was determined by comparing the results of an X-ray analysis (by the Debye Scherrer powder diffraction method) with those of a chemical analysis. Two clay samples from Marchagee were shown to consist almost entirely (apart from non-clay minerals) of a montmorillonite-type clay (saponite), while a sample from Cardabia contained a mixture of the montmorillonoid, kaolin and mica types.

OCCURRENCE.

The samples were collected from Cardabia and Marchagee (*see* text fig. 1) by Sofoulis (1) and Glance (2) of the Geological Survey. The beds at Cardabia formed part of a Cretaceous sequence, and were exposed by erosion of the crest of a broad anticline. The " bentonite "* layer bottoms on Radiolarian siltstone, and is overlain by *Inoceramus* marl and limestone. Its thickness has been estimated at about 10 ft., and the area of the deposit is about 38 sq. miles.



The bentonite at Marchagee has been commercially worked for some years. It is of recent formation, and occurs in the form of claypans in the bed of a larger lake depression, which is limestone of possibly Cretaceous age. The total area covered by the bentonitic clay-pans amounts to about 1/8 sq. mile. On the particular mineral claim from which our samples were taken (M.C. 397H), there is the following downward sequence :—

1. Top bentonite layer, about 10 in. thich (Top Layer.)
2. Gypseous clay about 11 in. thick.
3. Lower bentonite layer, about 13 in. thick (Bottom Layer).
4. White limey sand.

ANALYSIS.

The cylindrical diffraction camera described by Shearer (3) was of radius 2·865 cms., with slit of dimensions 0·4 x 2·5 mm., and line spacings on the film were estimated visually to 0·1 mm. The camera recorded spacings between about 1·3A and 20A, using cobalt K radiation.

* Local clays, rich in montmorillonite, are referred to in References (1) and (2) as bentonites. This term will be hereafter retained.

All specimens examined comprised clay material as collected. Two methods of mounting were used. In one, a slot slightly smaller in cross section than the collimating slit was cut in celluloid 0·2 mm. thick. Into this slot the powder was packed. In the second method of mounting, yielding higher sensitivity in analysis, the aggregate technique described by Nagelschmidt (4) was employed. A flake of ordered aggregate material was mounted in front of the slit parallel to the X-ray beam. In some cases, this type of specimen was treated with glycerol, in order to obtain a montmorillonoid complex with a stable basal spacing (5). This valuable technique removes the uncertainty caused by the variation of the basal spacings of montmorillonoids with their degree of hydration. The camera was calibrated for powder specimens, using the known spacings of KCl and borax, and a correction curve drawn. The same calibration was observed to hold for the second method of mounting.

The observed d/n for basal spacings, using unfiltered radiation, was too high ; but after making exposures using an iron filter, it was concluded that at these small Bragg angles, the α and β lines were unresolved, resulting in an effective increase of the spacing.

The values of d/n were identified using a recent publication on clay minerals by the Mineralogical Society (6) and also the revised A.S.T.M. card index (7) ; the approximate composition was then estimated by visual observation of the line intensities on the photographs.

Auxilliary tests made to confirm the analysis included heat-treatment of the montmorillonite and kaolin-type clays.

The observed spacings and their identification are given in Tables 1 and 2, where the composition arrived at by X-ray methods alone is compared with the figure subsequently obtained by employing the chemical analyses also.

TABLE 1.

Marchagee Bentonite—(Glycerol Treated).

Top Layer.			Bottom Layer		
Intensity	d/n (A).	Identification.	Intensity	d/n (A).	Identification.
VS	18.	Mo	VS	18.	Mo
VW	12.	Se	VW	12.	Se
M	9.1	Mo	M	9.0	Mo
VW	5.9	Mo	VW	6.1	Mo
M	4.52	Mo + Se			
W	4.25	Q			
W	3.54	Mo	M-W	3.53	Mo
M	3.34	Q	M-W	3.35	Q
S	3.03	Cal	M	3.03	Cal
			W	2.92	Mo
M	{ 2.60	Mo + Se	M-W	2.58 }	Mo,Se
	2.48	Se	W	2.49 }	Se
M	2.28	Cal + Se	W	2.28	Cal,Se
			VVW	2.20	
M — W	2.09	Cal + Se	W	2.10	Cal,Se
W	1.92	Cal			
M — W	1.87	Cal	VW	1.88	Cal
W	1.68 ± 0.2	Mo	VVW	1.60	
S	1.53	Mo, Q	M	1.53	Mo, Q
VW	1.46		W	1.32	Mo
VW	1.38	Q			
VW	1.32	Mo			

Abbreviations : Mo = Montmorillonite ; Q = Quartz ; Se = Sepiolite ; Cal = Calcite.

Approximate Percentage Composition.

From X-ray Data.		From X-ray data and chemical analysis.	
Trioctahedral Mo Clay	75	Saponite	75
Calcite	15	Calcite	8
Quartz	10	Free Silica	11
Sepiolite	Trace	Sepiolite	3
(There may be slightly more sepiolite in Bottom Layer than in Top Layer.)		(Salts and Oxides	3)

TABLE 2.

Cardabia Bentonite.

Intensity	d/n (A).	Identification.
VS	15.9	Mo
W	10.1	Mica Clay
W	8.9	?
VW	7.9	Mo or Ka/β
S	7.15	Ka
W	4.46	Mo, Mica
W	4.24	Q
W	3.96	Ka/β
VVW	3.70	Q/β
M	3.57	Ka
M–S	3.34	Q, Mica
W	3.16	Mica?
W	2.98	Mica
VW	2.80	Mica
M–W	2.57	Mica, Mo, Ka
VW	2.46	Ka, Mica?
VW	2.38	Ka
W	2.13	Mica
W	2.00	Mica
W	1.81	Q
W	1.66	Ka, Mica
VW	1.54	Ka, Q.
W	1.50	Ka, Mo, Mica
W	1.38	Q
VVW	1.30	Mica

Abbreviations : Mo = Montmorillonite ; Ka = Kaolinite ; Q = Quartz.

Approximate Percentage Composition.

From X-ray Data.		From X-ray data and chemical analysis.	
Dioctahedral Mo Clay	40	Nontronite	40
Kaolinite	30	Kaolinite	25
Mica Clay	20	Mica (Muscovite or illite)	20
Quartz	10	Free Silica	15

Chemical analyses were carried out by D. Burns, Mineralogical Chemist and Research Officer in the Government Chemical Laboratories. These confirmed the X-ray analyses, and allowed more definite conclusions to be made as to the proportions and type of minerals present.

In the case of the Marchagee sample, two chemical analyses were made—one on portion of the material used in X-ray analyses, and one on the finest fraction ($> 2\,\mu$) after removal of silt. It is to be expected that the percentage of those elements associated with the clay mineral itself will be increased in this "clay fraction," whereas the percentage of those associated with non-clay minerals, which are normally of relatively large grain-size, will be reduced. From these analyses an estimation of the free silica was made, by comparison of the magnesia—silica ratios, and the nature of the montmorillonoid clay was more reliably checked. "Free silica" could include the silica content of any non-clay silicates such as felspars, etc.

Table 3 compares the percentages by weight in the aggregate (from the chemical analyses) with those of a hypothetical specimen composed of the sum of the minerals found from the X-ray data. The compositions are typical of the various minerals, and are obtained either from the formula or from actual chemical analyses as appearing in (6) or (7). The percentages in which the minerals are combined have been adjusted to give best agreement with the chemical analyses.

The percentages of silica and calcite were fixed by comparing the two chemical analyses (the X-ray evidence suggested a considerably higher figure for calcite), a trace of sepiolite was added, and most of the remainder was attributed to saponite, a trioctahedral montmorillonoid clay rich in magnesium. There were also chemical traces of salts, oxides and silicates in too small proportions to give an X-ray pattern.

TABLE 3.

Marchagee Bentonite (Top Layer).

——	8 per cent. Calcite.	11 per cent. Free Silica.	3 per cent. Sepiolite.	75 per cent. Saponite.	Total.	Chemical Analysis.	
						Aggregate.	Silt-Free.
SiO_2	....	11.0	1.5	34.0	46.5	46.80	41.79
Al_2O_3	....	....	....	5.0	5.0	5.01	5.35
Fe_2O_3	....	....	0.1	2.5	2.6	2.62	2.96
FeO	....	....	....	....	....	0.54	0.16
MgO	....	....	0.6	17.6	18.2	18.19	21.12
CaO	4.5	....	....	....	4.5	5.15	4.84
H_2O+	....	....	0.6	15.0	15.6	6.33	6.61
H_2O-						9.03	12.60
CO_2	3.5	....	....	....	3.5	3.97	3.19
MnO	....	....	....	....	....	0.08	0.08
K_2O	....	....	....	....	....	0.28	0.28
Na_2O	....	....	....	....	....	1.34	0.52
TiO_2	....	....	....	....	....	0.29	0.28
C (Humus)....	....	....	....	....	....	0.50	0.52
SO_3	....	....	....	....	....	0.10	0.04
Cl	....	....	....	....	....	0.44	0.06
Total	8.0	11.0	2.8	74.1	95.9	100.67	100.40

The composition of the Cardabia sample could be less definitely established, as it was made up of three clays, the composition of each of which is variable within limits.

Table 4 compares the chemical analysis of the sample with that of a hypothetical sample composed of the three types of clays in the proportions shown. The balance of the water found chemically, after satisfying the kaolinite and the mica, was all assigned to the nontronite. The 9A line could be due to talc, pyrophyllite, or a zeolite.

The iron and alumina of nontronites and beidellites are mutually interchangeable within wide limits, accounting for the discrepancy in these figures.

TABLE 4.

Cardabia Bentonite.

——	15 per cent. Free Silica.	20 per cent. Mica (Muscovite or Illite).	25 per cent. Kaolinite.	40 per cent. Nontronite.	Total.	Chemical Analysis.
SiO_2	15.0	10.3	11.6	16.5	53.4	53.51
Al_2O_3	....	5.2	9.9	0.7	15.8	17.65
Fe_2O_3	....	0.8	....	9.5	10.3	8.38
MgO	....	0.6	....	1.4	2.0	2.22
K_2O	....	1.4	....	....	1.4	1.29
Na_2O	....	....	....	....	....	1.53
H_2O+ .... }	....	1.4	3.5	8.0	12.9	{ 5.87
H_2O- .... }						7.06
FeO	....	....	....	....	....	0.08
CaO	....	....	....	....	....	0.18
TiO_2	....	....	....	....	....	0.67
CO_2	....	....	....	....	....	0.26
C (Humus)	....	....	....	....	....	0.48
SO_3	....	....	....	....	....	0.58
Cl	....	....	....	....	....	0.41
Total	15.0	19.7	25.0	36.1	95.8	100.17

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